General Geology of West Face of Southern Gunung Semanggol Transect,

With Emphasis on

Tectonic Evolution of the Area.

By

Azri Afif Bin Rosli

13710

Dissertation submitted in partial fulfilment of

The requirements for the

Bachelor of Technology (Hons)

(Petroleum Geoscience)

MAY 2014

Universiti Teknologi PETRONAS

Bandar Seri Iskandar

31750 Tronoh

Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

General Geology of Southern Gunung Semanggol Transect, Bukit Merah,

Taiping with Emphasis on

Tectonic Evolution of the Area.

By

Azri Afif Bin Rosli

13710

A Project Dissertation Submitted to

The Petroleum Geoscience Programme,

UNIVERISIT TEKNOLOGI PETRONAS,

In Partial Fulfilment of the Requirement for the

BACHELOR OF TECHNOLOGY (Hons)

(PETROLEUM GEOSCIENCE)

Approved by,

____

MR MD YAZID B MANSOR

Universiti Teknologi PETRONAS

Bandar Seri Iskandar

31750 Tronoh

Perak Darul Ridzuan

____

MUHD. SHAUFI B. SOKIMAN

Universiti Teknologi PETRONAS

Bandar Seri Iskandar

31750 Tronoh

Perak Darul Ridzuan

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

By:

____

AZRI AFIF BIN ROSLI

ABSTRACT

This research will be focused mainly on the general geology of West Face of Southern Gunung Semanggol and will be emphasize on tectonic evolution of the transect area. Semanggol Formation in Northwest side which is in Perak area is generally the typical Permo - Triassic rock which can be categorized in three types of rock, Sandstone, Conglomerates, and Chert. The oldest rock in this formation is the chert which probably come from Permian period, followed by sandstone and the youngest one is conglomerates. This formation is Young towards Northeast which has a lot of conglomerate was found towards there (Burton, 1973). Structures in the Semanggol range is said to be a very tight folding structure and consists of a series of asymmetrical folds having north-south trend. All the information gathered was used to generate the Geological map of the transect area, the topography profile cross section also being generated. These map and cross section are to show the distribution of the types of rock in the area and also the elevation of the transect area. The observations, measurements, and samples are taken to build a theory model of tectonic evolution process. Some lab analysis such as Petrography works from Thin Section analysis and XRF analysis are done to confirm the lithology in the transect area. Finally, model of the Gunung Semanggol is being modeled based on the features, data obtained from the lab analysis, lithology found, and tectonic evolution theory.

ACKNOWLEDGEMENT

Alhamdulilah, first of all I would like thank god as finally I was able to finish my final year project. First of all, I would like to offer my deepest appreciation to Department of Geosciences, Faculty of Geosciences and Petroleum Engineering Universiti Teknologi PETRONAS (UTP) for giving me a chance to undergo this Final year project for two semesters.

This research project would not have been possible without the support of many people. I would like wishes to express my gratitude to my supervisors, Mr. Md Yazid B. Mansor and Mr. Shaufi B. Sokiman for guidance and encouragement in carrying out this project. The supervision and support that they gave truly help the progression and smoothness of the final year project. The cooperation from both of them are much indeed appreciated. A big contribution and hard worked from them during the two semesters are very great indeed. The works during the project would be nothing without the enthusiasm and help from them.

I also wish to express my gratitude to all the lecturers and technicians of Department of Geosciences, Faculty of Geosciences and Petroleum Engineering, who rendered their help during the progress works of my Final Year Project work, especially during the rock sampling, and lab analysis interpretations. The whole project that they involved really brought me together to appreciate and respect to each other.

Finally, an honorable mention goes to my families and colleagues for being supportive towards me for the last two semesters, thus making my Final Year Project a great success. Without their helps of the particular that mentioned above, I would face many difficulties while doing this project. Thank you.

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The study is being conducted in West Face of Southern Gunung Semanggol which is located around 13 kilometres Northwest of Taiping (Foo Khong Yee, 1990). Gunung Semanggol forms a distinct topographic unit of Triassic rocks. It is actually a small narrow range of hills that trending in a North-South direction. Gunung Semanggol's highest peak is about 390 metres above the seal level and it is located on the southern range. This study was focused on the West Face side of Gunung Semanggol, the other part of Gunung Semanggol were also included with less details. The total area covered by the transect is about 3km X 3km. Gunung Semanggol area in Bukit Merah actually one of area under the Semanggol Formation which is named by Alexander in 1959. Overall, this paper will discuss on the general geology of the transect area with concern, and emphasize on the tectonic evolution of the area.

1.2 Problem Statement

The main objectives of this paper are focusing on the general geology setting of the Gunung Semanggol area. A lot of research papers only published about general geology of Semanggol Formation in the North Kedah like Baling, Kodiang, Bedung and so on, only some of the papers that describe the general geology in the Gunung Semanggol's transect and they are already outdated which was published in about two to three decades ago. Hence, this begging a question of what is the general geology of the Southern Gunung Semanggol especially on the West Face and also how the Gunung Semanggol is formed in term of tectono stratigraphic evolution?

1.3 Objectives

The main objectives of this project are:

1. To study the geological setting of the area including the structural geology, sedimentary features, lithology and lithofacies of the area.
2. To produce a good geological map, cross section, lithology map, and traverse map in details.
3. To produce a model of how Gunung Semanggol is formed in term of tectono stratigraphic evolution.

1.4 Scope of Study

In this project, the author's main purpose is to make a research about general geology in the given area which is at the West Face of Southern Gunung Semanggol transect. This research will include all the basic geology knowledge in order to fulfil the objectives. This basic geology includes the interpretation skills, the theory of structural geology, the mapping skills, and the sedimentology and so on. This project gives the author a lot of challenges especially when surveying the sites, this is because the outcrops are mostly located about 500m interval to each other which kind of difficult to correlate to each other. The other challenge is of course the time frame, the author need to complete this project in these two semesters, which is about total 40 weeks, the only free time is only on weekend which the author don't have any lectures.

CHAPTER 2

LITERATURE REVIEW

2.1 Semanggol Formation

'Semanggol Formation' was first used by Alexander in 1959 to designate the sediment exposed in the Semanggol range. West Face of Gunung Semanggol basically is some of the exposed of Semanggol Formation. Semanggol Formation occupies area of $269km^2$ or about 35.2% of the area under survey. Semanggol Formation also extend its outcrop to the East of Baling area and to the South of Kulim. The thickness of this formation could not be determined due to the tightly folded nature of the rocks and the absence of marker horizons or beds, but the sequence is believed to be no less than 760m thick, (Foo Khong Yee, 1990).

2.2 Lithology

Lithology in this area, especially in Gunung Semanggol consist of two dominant facies which are; a rudeceous-arenaceous facies of intraformal conglomerates and sandstone, and an argillo-arenaceous facies of rythmically bedded sandstone with a few bands of cherts and shale. Conglomerates also present in this area and forms the thickest beds and occurs interbedded with less-sorted sandstone at different horizons in the Semanggol Formation.

While arenaceous means that the rocks resembling or containing high percentage of sand; or growing in sandy areas. The arenaceous rocks include all those classic rocks whose particle size range from 2 to 1/16 mm, or if silt is included, to 1/256 mm. The vast majority of arenites are commonly called sandstone. The arenites present include greywacke, subgreywacke, and photoquartzite.

Besides that, Semanggol Formation also contain minor intercallations of siltstone and chert, (D.B Courtier, 1974). The chert can be seen in every sedimentary sequence of the map area especially in Southern Gunung Semanggol. It is notable to mention that, the chert is present in every sedimentary sequence of the map area, although they are widely differing ages. The chert is characterized by a very wide of colours from the light colour like white to the very dark colour like black. The chert of the Semanggol Formation is relatively free from impurities, (Courtier, 1974).

In 1970, Burton also described that Semanggol Formation as a rapidly alternating sequence of shale, siltstone and sandstone with a few bands of chert. A single member of the bed usually have a thickness of ranging from a milimetre to a few ten metres. He also added that, the contacts between beds normally are sharply defined.

The Semanggol Formation can be divided into three members, which are; Chert, Ryhtmite, and Conglomerate members as being stated by Burton in 1973. Courtier changed the Chert Member into Tawar Formation after he finished mapped the area. Besides that, Semanggol Formation also is youngs towards the East or Southeast as being suggested by Burton in 1973. This can indirectly conclude that the Chert Members as the oldest rock and the Conglomerate Members as the youngest rock which is located in the Gunung Semanggol.

2.3 Structural Geology

The sedimentary layer at Gunung Semanggol is folded and consists of sandstone-shale interbed overlying the lower rudaceous as being explained by Foo in 1990. Other than that, a regional fold axis was identified to the extreme west of the exposed Trias that composed of an anticlinal axis which trend northwest following the Semanggol range itself. This can be concluded that the structure is a slightly asymmetric anticlinorium with the axial plane dipping very steeply westwards. In addition, isoclinals, locals' flexure and accordion folds also have been found in the Semanggol range.

2.4 Metamorphism

The rocks of Semanggol Formation mostly have undergone some degree of regional metamorphism to the folding of the sediments as being explained by Foo in 1990. For Semanggol Formation, the metamorphism is being described as generally very low and essentially involved processes of induration and partial recrystallization of the sediments. Besides that, quartzite and indurated siltstone and subgreywackes also can be found in the rythmict facies. This make the shale contain of a faint slaty cleavage which is better developed tin that found in the Gunung Semanggol. Other than that, the regional metamorphism also had been identified to affect the induration for conglomerates and sandstone through cementation and pressure.

2.5 Age

According to Basir (1996, 2001), Radiolarian chert deposits are quite widespread especially in the Late Paleozoic and Early Mesozoic of the Western Belt of Peninsular Malaysia. Radiolarian cherts were more extensive in Permian and eight radiolarian assemblage zones were recognized and most of them were identified from the Triassic rocks which is in Semanggol Formation. The cherty unit in the semanggol formation was considered as the lower part of the Permian - Triassic Semanggol formation (The Malaysian and Thai Working Group, 2012). This Radiolarians are actually planktonic protozoa that are widely distributed in the Oceans, throughout the water columns from the near surface to the bottom waters. They are abundant organism record and the oldest know fossils contributing enormously to the history of the useful in biostratigraphy because of their size and abundance.

CHAPTER 3

METHODOLOGY

3.1 Data Collection

Data collection is the first step in doing this project because it is very important as it gathered the information related to the project from various sources, mostly from academic publication such as previous research papers which got from the library and also from the lecturers. Information gathered comprised the basic information, geological background, and also previous studies one of the area. The data collected will be used as a guideline and parameters to proceed the project.

3.2 Geological Fieldwork

Fieldwork is conducted by the author itself with supervision and permission from the supervisor. Before the fieldtrip, some important issues need to be highlighted such as Health, Safety and Environment (HSE) issue, equipment, accessibility to the outcrop, and permissions. All of these are prepared before the fieldwork.

Equipment for geological fieldwork are Brunton Compass, geological hammer, hand lens, Global Positioning Systems (GPS), topography map, sampling bag, hardcopy field notebook and of course Personal Protective Equipment (PPE). All of these equipment are inspected and checked to make sure all follows the HSE rules and regulations.

During the fieldwork, observation in details of the outcrops is a must. The outcrops are being analyses and interpret using the available data such as a visible faults, folding, slumps, types of rock and lithology and so on. Some measurements are being collected and recorded for future used in analysing process. Dip and strike for visible outcrops also being measure using Brunton Compass and recorded in a table format.

Topography map and GPS are used to locate and mark the outcrops in the area to make sure that the outcrops are still in the transect area. The coordinates of the outcrops are being recorded and tabulated in the field notebook. Both of these equipments also are used for road traversing and river traversing if there is any.

For rock sampling, sample are being taken from the outcrops using the geological hammer and put in sampling bag with a brief descriptions and labelling. Some of the rocks are very fragile and also some are very hard. So, safety precautions is very important, and to avoid any bad incident happens, safety goggle and glove are being wore. Once the sample have been taken and put into sampling bag, the bag is being labelled accordingly with a brief description of rock type, location and outcrop name.

3.3 Mapping

A geologic map is a must when conducting the geological fieldwork. A geologic map is a special-purpose map made to show geological features in the area. Rock units or geologic strata are shown by colour or symbols to indicate where they are exposed at the surface. Bedding planes and structural features such as faults, folds, foliations and lineations are shown with strike and dip which give these features' three-dimesional orientations. Data collected during the geological fieldwork are fully used in the mapping. Types of rock are typically usually represented by colour. The boundary of the area is stated clearly using the data gathered during the fieldtrip to make sure all the outcrops can be correlate to each other in the same area.

Besides that, cross section based on the geological map also is being generated to give more details about the geological information in the area. Cross section is generated after the geological map is done. Cross section map is an interpretation of a vertical section through the Earth's surface for which evidence was obtained by geologic and geophysical techniques. Other than that, road traverse map, lithology map, topography map, and aerial map are also prepared to give more information in the transect area.

3.4 Stratigraphic Log

Stratigraphic log is a representation used in geology and its subfield of stratigraphic to describe the vertical location of rock units in a particular area. This log will shows a sequence of sedimentary rocks, with the oldest rocks on the bottom and the youngest on top. The important features that should be in the log are scale, grain size, lithology, depth, geological interpretation, and some comments that will tell about its structure, present of fossils and so on.

This log is generated after all the observations and interpretations of the outcrops finished. All the data recorded that are related are being converted into this stratigraphic log to give more explanation in details

3.5 Laboratory Analysis

The rocks samples are then being analyses in Thin Section Lab to identify the optical properties of the minerals in the rocks which includes the mineral content and also the textural relationships within the rock. This observations will give more information and also more understanding the origin of the rock. Other than that, Scanning Electron Microscope (SEM) also will be run if there is a sufficient time. This analysis is a type of electron microscope that produces images of a sample by scanning it with atoms in the sample, producing various signals that can be detected and that contain information about the sample's surface topography and composition.

3.6 Gantt Chart

Table 1: Gantt chart for Semester 1

Details / Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Selection of Project Title														
Preliminary Research Work														
Field Survey														
Submission of Extended Proposal						●								
Fieldwork 1														
Fieldwork 2														
Proposal Defence								●	●					
Fieldwork 3														
Project Work Continue														
Submission Draft of Interrim Report														
Submission of Interrim Report														●

Table 2: Gantt chart for semester 2.

Details / Week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Fieldwork 1														
Fieldwork 2														
Lab analysis (thin section)														
Submission Draft of Progress Report														
Submission of Progress Report														
Pre - SEDEX														
SEDEX														
Submission Final Report draft and Technical Paper Draft														
Submission of Dissertation (soft Bound) and Technical Paper														
VIVA														
Submission of Dissertation (Hard Bound) and Technical Paper														

= Key Milestone

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Outcrops Observations

4.1.1 Outcrop 1a (N11°55'15.7", E100°39'38.4" ±14m)

Figure 1 : Shows exposed small outcrops of Sandstone which dipping towards West side with Strike direction toward southwest.

This outcrop showed the some beds of sandstone with bands of chert which has been exposed. The thickness of this bedding is about 10cm to 15cm interbedded with thin layer of shale. But the shale is already being eroded due to weathering process. The outcrop can be correlate to the outcrop 1b which was found about 500m from this location. Both of these outcrops showed the same direction of dipping (west) and strike (southeast) with the same type of lithology. There are a few of this small outcrops found in the area which all showed the dipping towards West and the strike direction towards Southeast.

Figure 2: Shows a few quartz veins in the chert bedding.

Based on the research by Marin-Carbonne, J. (2013), this quartz vein is formed because of the chert itself can have a various origins (hydrothermal, sedimentary, volcanic silification) and their isotopic compositions might have been reset by metamorphic fluid circulation. The quartz vein is form because of the fluid circulation inside the chert. Several of fluid system condition will form different quartz habit and texture in their quartz vein.

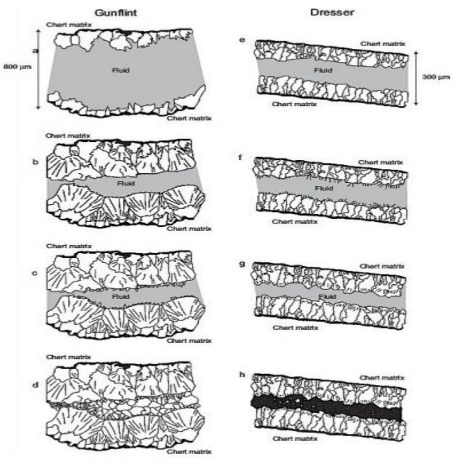


Figure 3: Two types formation of quartz vein in Chert modeled by Marin-Carbonne,J. (2013).

Table 3: Dip and Strike readings for outcrop 1a.

NO	STRIKE	DIP
1	203 SW	50 W
2	191 SW	42 W
3	199 SW	46 W
4	193 SW	46 W
5	192 SW	43 W
6	195 SW	47 W
7	196 SW	43 W
8	199 SW	40 W
9	197 SW	53 W
10	193 SW	54 W
11	202 SW	45 W
12	194 SW	57 W
13	194 SW	59 W
14	190 SW	50 W
15	188 SW	48 W
16	188 SW	49 W
17	186 SW	52 W
18	189 SW	57 W
19	191 SW	56 W
20	202 SW	41 W
21	195 SW	46 W
22	192 SW	48 W
23	195 SW	47 W
24	202 SW	56 W
25	199 SW	50 W
26	198 SW	45 W
27	193 SW	40 W
28	194 SW	48 W
29	201 SW	51 W
30	202 SW	52 W

Total no. Strike - Dip Readings : 30

Range of W Dips : 40° - 59°

Average Strike : 195.1°

Structural Analysis (Rose diagram)

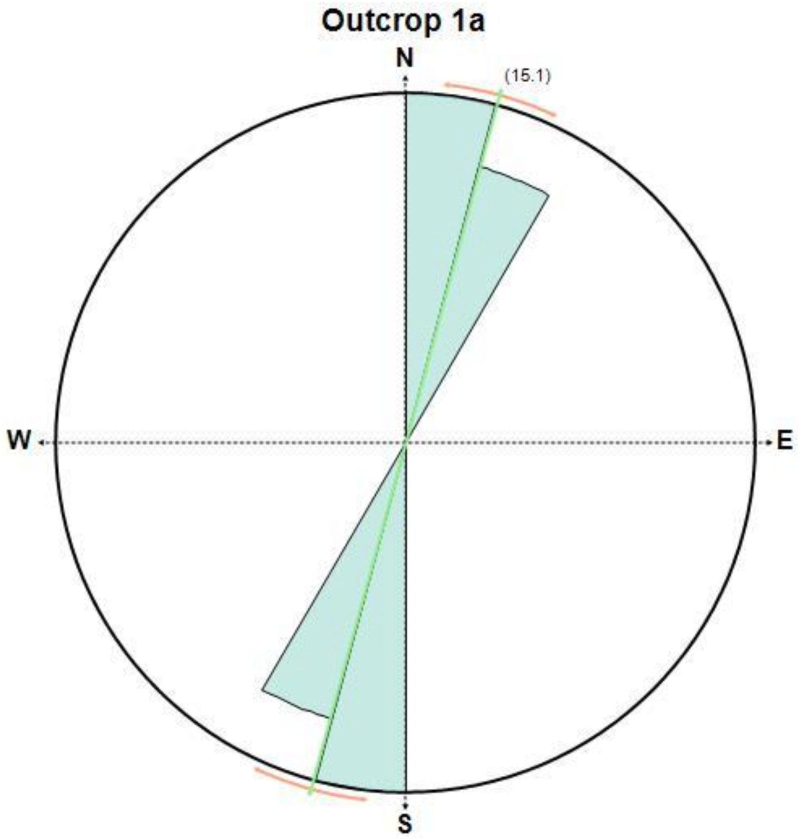


Figure 4: Rose Diagram for Outcrop 1a

Table 4: Analysis of Rose Diagram Outrop 1a

Number of Measurements	30
Largest class size	60%
Mean	195.10°
Standard Deviation	± 4.70°
Vector Magnitude	29.90
Consistency ratio	1.00

4.1.2 Outcrop 1b (N4°55'16.8", E100°39'41.6" ±3m)

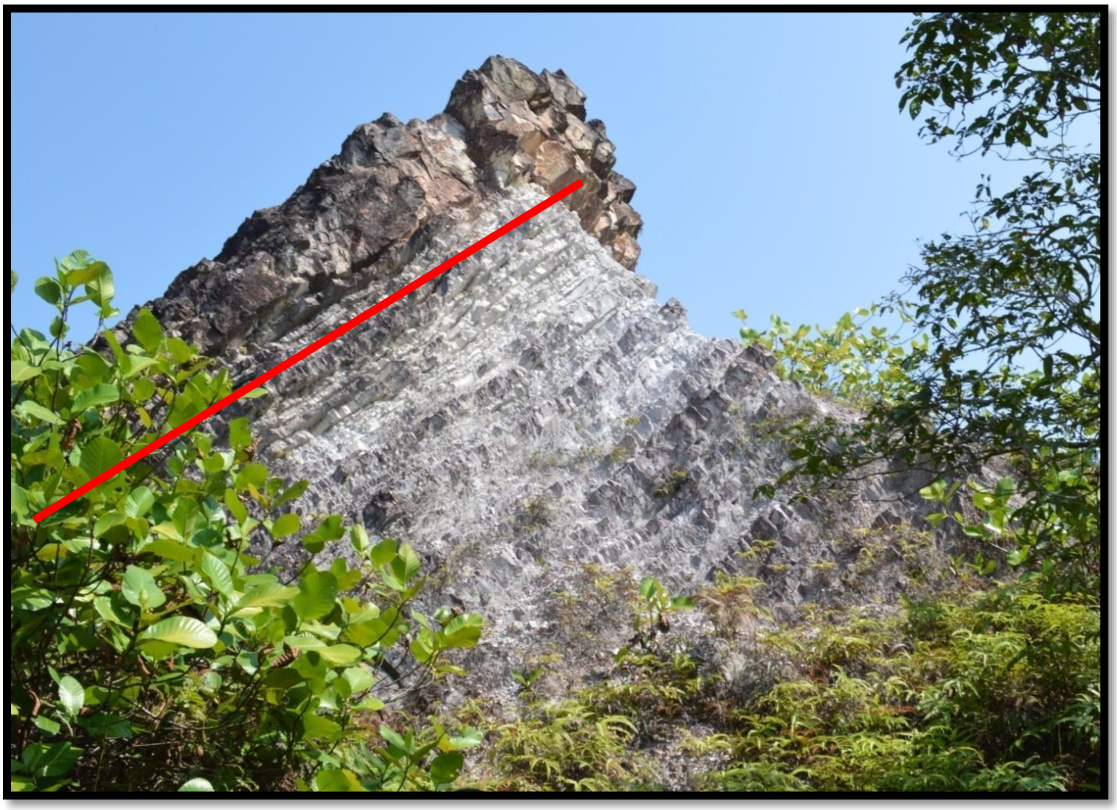


Figure 5: Exposed of thick sandstone on top of bedded chert with shales and mudstone in between.

In this area rocks of the Semanggol formation, the facies of alternating of sandstone with a few bands of bedded chert and mudstone, with minor siltstone and quartzite interbeds. The bedded chert contain high percentage of crystallized silica, the most familiar silica mineral is quartz which make it resistant to weathering and erosion processes. The chert is formed during the Permian period. The chert is light grey in colour but some are stained in brown colour which because of weathering process. It has a variable content of sand and clay material. The beds are thicker than mudstone, and the thickness varying about 2cm to 15cm. The mudstone beds have a thickness around several millimetres to centimetres thick. Lenticular and ovoid silty to sandy intercalations occur within the mudstone and chert bands. The top of the outcrop is a thick sandstone bedding about 1.2 metres thick which is probably come from Triassic period. There is a clearly visible contact in between Permian Chert with the Triassic Sandstone which is showed by the red line.

Figure 6: The sandstone is in brown colour due to the weathering process.

The thickest sandstone exposed on the outcrops is about 1.2 metres. The colour of the sandstone is brown to black due to highly weathered process. Most of the surface of the sandstone had been hardly oxidizing which make the colour go even darker than usual due to iron deposits during the weathering process. This sandstone is probably come from the Triassic period. The grain size of the sandstone is about medium to coarse grain.

Figure 7: Sandstone with bands of chert interbedded with shale and mudstone.

Figure 8: Thick Sandstone overlie on top of bedded cherts with shale in between.

Table 5: Dip and Strike reading for Outcrop 1b

NO	STRIKE	DIP	NO	STRIKE	DIP	NO	STRIKE	DIP
1	193 SW	50 W	**31**	168 SE	56 W	**61**	177 SE	60 W
2	194 SW	50 W	**32**	169 SE	54 W	**62**	176 SE	42 W
3	190 SW	59 W	**33**	172 SE	49 W	**63**	178 SE	47 W
4	188 SW	60 W	**34**	171 SE	47 W	**64**	171 SE	49 W
5	190 SW	57 W	**35**	170 SE	58 W	**65**	168 SE	59 W
6	188 SW	62 W	**36**	173 SE	43 W	**66**	170 SE	36 W
7	195 SW	42 W	**37**	178 SE	45 W	**67**	172 SE	60 W
8	187 SW	37 W	**38**	172 SE	47 W	**68**	174 SE	54 W
9	196 SW	40 W	**39**	171 SE	53 W	**69**	174 SE	60 W
10	197 SW	40 W	**40**	169 SE	51 W	**70**	172 SE	57 W
11	190 SW	55 W	**41**	168 SE	50 W	**71**	174 SE	50 W
12	194 SW	52 W	**42**	172 SE	52 W	**72**	172 SE	57 W
13	194 SW	53 W	**43**	170 SE	47 W	**73**	167 SE	51 W
14	191 SW	41 W	**44**	171 SE	49 W	**74**	169 SE	55 W
15	193 SW	48 W	**45**	173 SE	40 W	**75**	168 SE	57 W
16	191 SW	49 W	**46**	169 SE	39 W	**76**	174 SE	50 W
17	195 SW	52 W	**47**	167 SE	45 W	**77**	174 SE	52 W
18	188 SW	54 W	**48**	168 SE	42 W	**78**	175 SE	54 W
19	193 SW	56 W	**49**	171 SE	50 W	**79**	176 SE	61 W
20	189 SW	49 W	**50**	169 SE	51 W	**80**	170 SE	68 W
21	194 SW	38 W	**51**	167 SE	46 W	**81**	169 SE	65 W
22	192 SW	43 W	**52**	169 SE	58 W	**82**	169 SE	66 W
23	189 SW	61 W	**53**	168 SE	61 W	**83**	169 SE	66 W
24	197 SW	56 W	**54**	172 SE	62 W	**84**	174 SE	58 W
25	191 SW	50 W	**55**	175 SE	59 W	**85**	169 SE	50 W
26	193 SW	47 W	**56**	174 SE	51 W	**86**	167 SE	63 W
27	193 SW	40 W	**57**	176 SE	48 W	**87**	168 SE	63 W
28	194 SW	44 W	**58**	172 SE	45 W	**88**	172 SE	56 W
29	189 SW	51 W	**59**	175 SE	49 W	**89**	171 SE	58 W
30	192 SW	52 W	**60**	177 SE	42 W	**90**	169 SE	57 W

Total no. Strike - Dip Readings : 90

Range of W Dips : 36° - 66°

Average Strike : 176.4°

Structural Analysis (Rose Diagram)

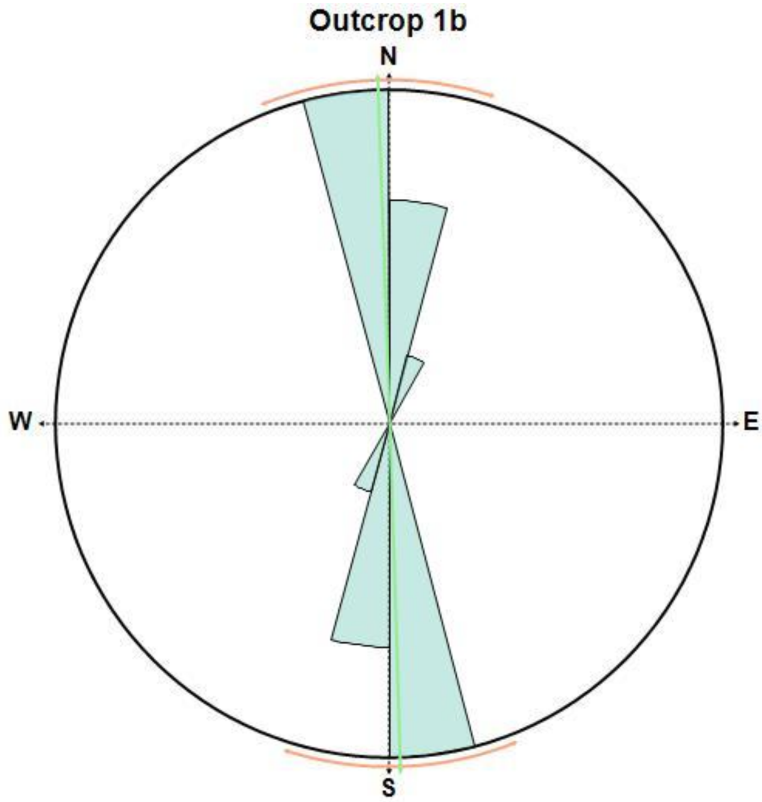


Figure 9: Rose Diagram for Outcrop 1b.

Table 6: Analysis of rose diagram for Outrop 1b

Number of Measurements	90
Largest class size	67%
Mean	-1.87°
Standard Deviation	± 20.10°
Vector Magnitude	84.46
Consistency ratio	0.94

4.1.3 Outcrop 2a

Coordinates: N4°55'39.38", E100°39'35.11"

Figure 10: Conglomerates boulder which is probably resulted from volcanic explosion.

This boulder of conglomerates are about 20 metres of length and about 5 metres of height. This conglomerates are probably resulted from the volcanic explosion about 75,000 years ago. The nearest volcano which erupted about 75,000 years ago is the Volcano Toba which is located in Sumatra, Indonesia. The Toba super eruption was a super volcanic eruption which is one of the Earth's largest known eruption. The Toba eruption took place in Indonesia and deposited an ash layer about 15 cm thick over the whole of South Asia. The volcanic ash from the eruption also deposited over the Indian Ocean, and the Arabian and South China Sea.

This conglomerate can be define as a pyroclastic breccia which is a subtypes of Volcanic Breccia. Pyroclastic breccia is formed by explosive of volcanic eruption, either magmatic or phreatic eruptions. This pyroclastic breccia is then deposited by air-falls at Gunung Semanggol.

Figure 11: The conglomerate showed the mixed of rounded clasts and angular clasts.

This conglomerate also can be define as a Polymitic conglomerate which is a conglomerate in which clasts include several different rock types. Polymitic conglomerates that include clasts from a wide variety of source rocks, possibly derived over a wide geographical area.

The conglomerate showed that the clasts are touched to each other which can be termed as Clast-supported types that consists of 60 - 65% of clast by volume. The cement of the conglomerate are in whitish colour which is probably solidified crystallized of pyroclastic ash.

Figure 12: Angular clasts of conglomerate are fragments of volcanic rock during the explosion.

Figure 13: Sampling of the conglomerate need to be coring as the conglomerate is so hard due to the welded cement.

Figure 14: Two samples of the conglomerate in core types.

4.1.4 Outcrop 2b (N4°55'39.67", E100°39'34.25")

Figure 15: Conglomerate boulder sized about 8 metres of height.

Figure 16: Very poor sorting of clast with mixture of angular and rounded texture.

The conglomerate block is found about 100 metres north from the Outcrop 2a which has a same type of conglomerate cement and types of clasts. But this one is much more looks like matrix supported compare to the conglomerate at Outcrop 2a. The cement of conglomerate is white in colour which is probably from the volcanic ash or the coarse pyroclastic of the volcano.

4.2 Maps Generated

4.2.1 Aerial Photograph

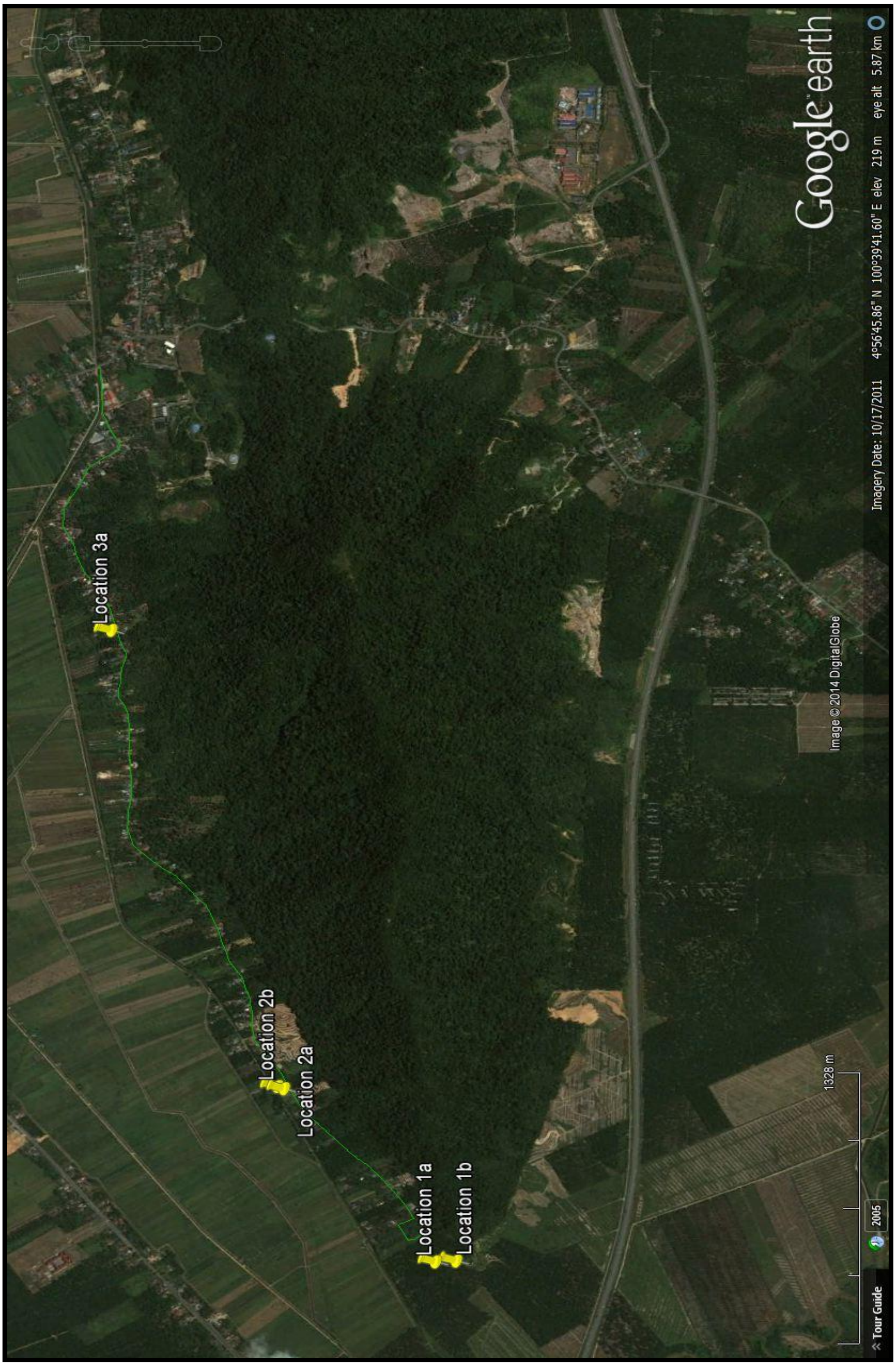


Figure 17: Aerial photograph of the transect area.

4.2.2 Road Traverse

Road traversing has been done as a part of fieldtrips where few rough observations have been made on the structure and formations. The pathway started from the North side of Kampung Gng. Semanggol and going downwards to the South. The total of distance have been calculated to be roughly about 5 km. Every 50 metres, the coordinates from the GPS is marked to keep the data. The coordinates for the marked points are tabulated below:

Table 7: Lattitude and Longitude points marked.

POINT	LATITUDE	LONGITUDE
1	4°57'35.38"N	100°39'3.29"E
2	4°57'22.65"N	100°39'6.54"E
3	4°57'12.62"N	100°38'59.62"E
4	4°56'56.30"N	100°39'6.31"E
5	4°56'37.95"N	100°39'9.99"E
6	4°56'21.22"N	100°39'10.46"E
7	4°56'9.04"N	100°39'21.57"E
8	4°55'50.81"N	100°39'28.56"E
9	4°55'31.59"N	100°39'41.12"E
10	4°55'17.72"N	100°39'52.84"E

Road Traverse Map

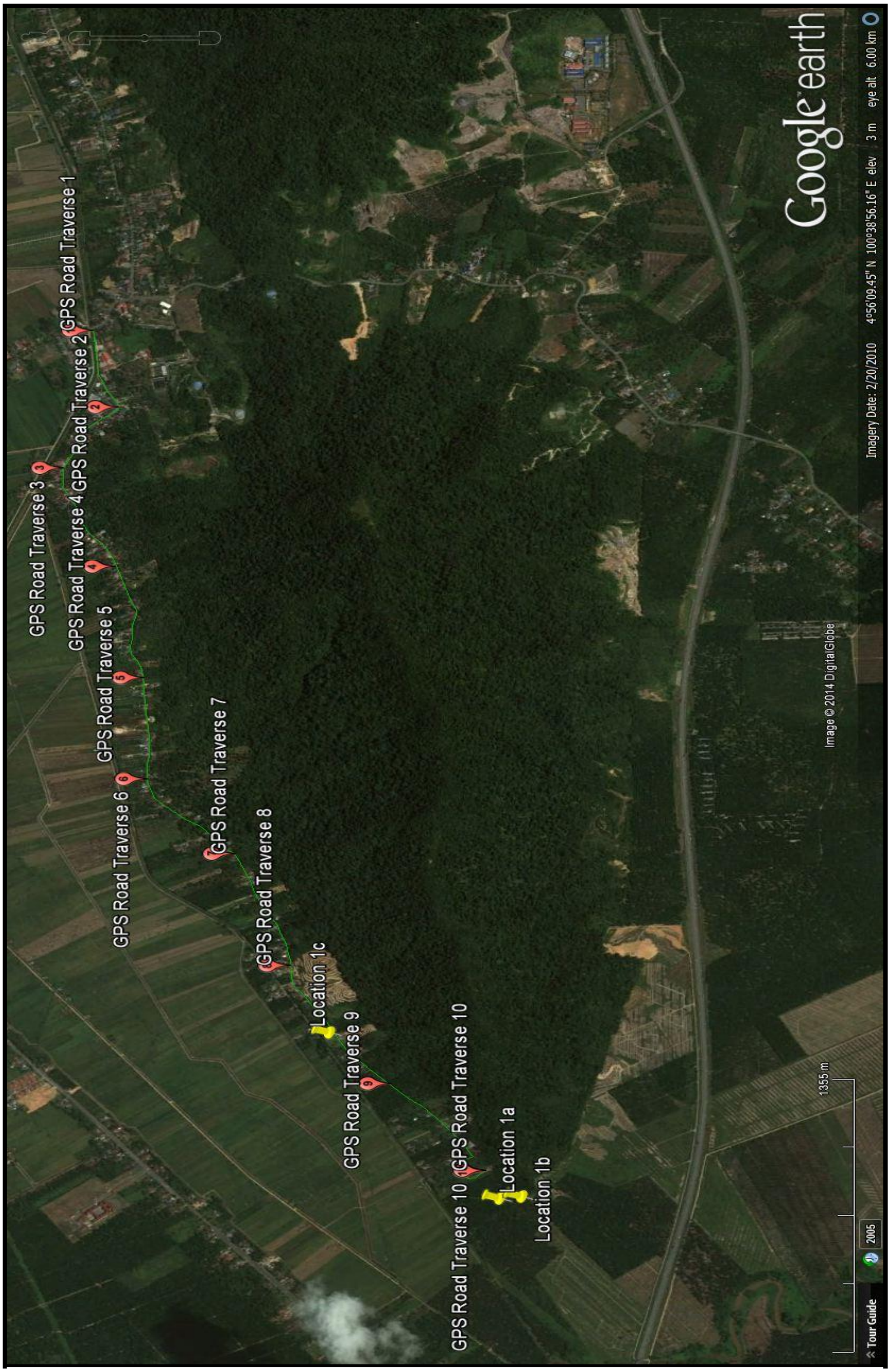


Figure 18: Road Traverse map on the transect area.

4.2.3 Topography Basemap

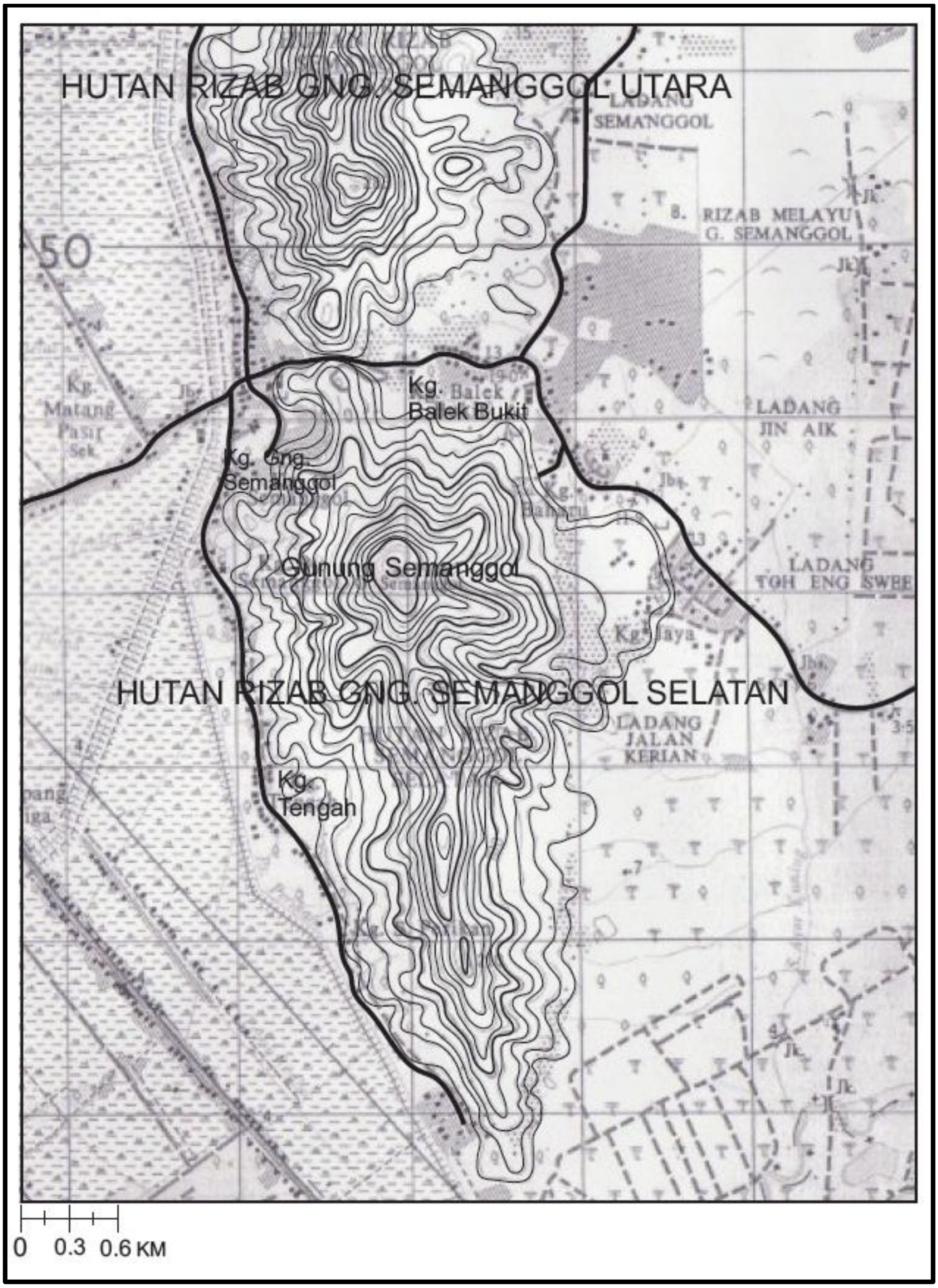


Figure 19: Topography base map of the transect area.

4.2.4 Structural Analysis Map

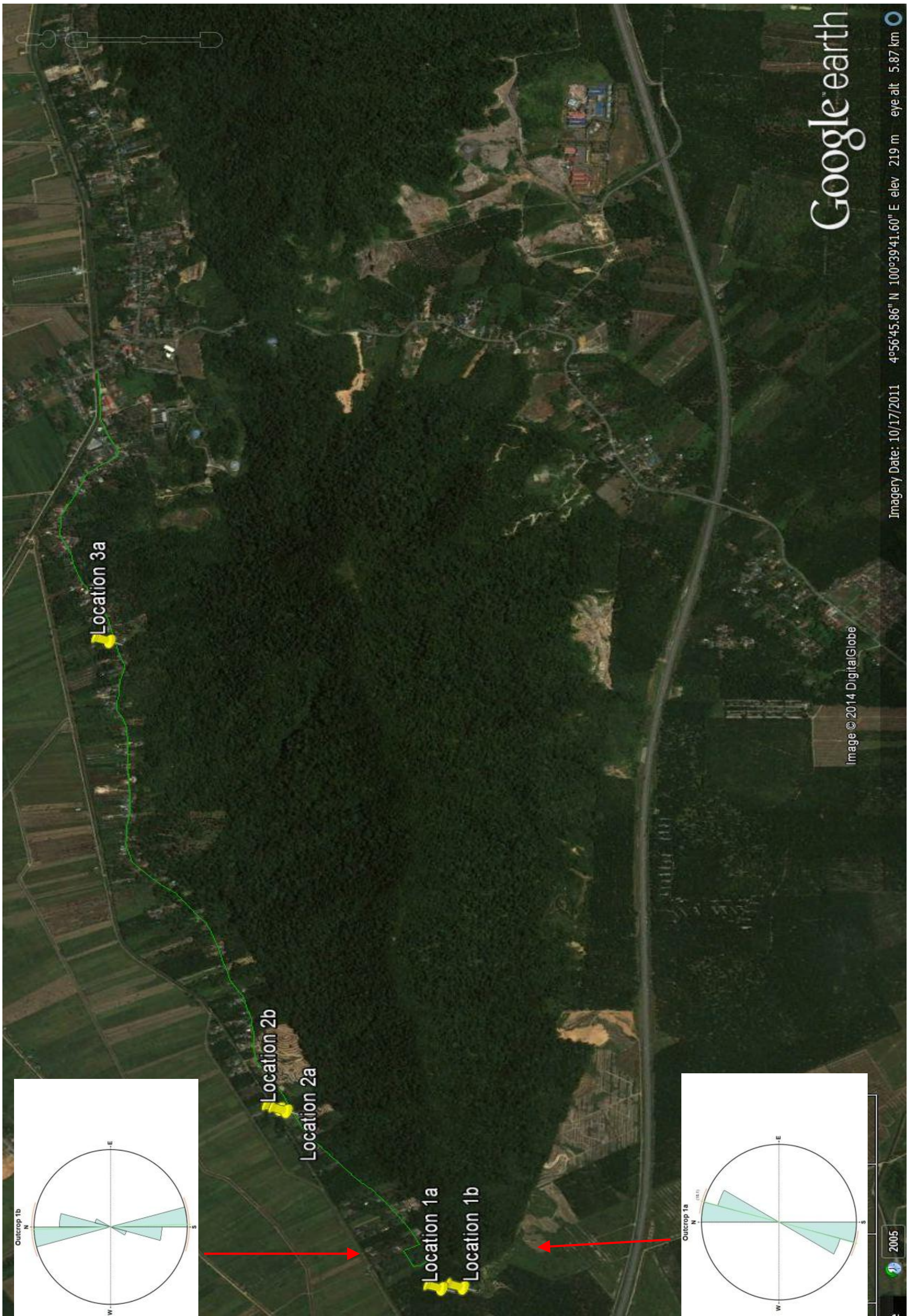


Figure 20: Structural Analysis map of the transect area.

Structural analysis was done at Outcrop 1a and Outcrop 1b. For Outcrop 1a, there are about 30 strike direction reading for the beddings taken, and about 90 strike direction readings taken for bedding at Outcrop 1b. Based on the measurements taken, Rose Diagram analysis was generated for each outcrops. As the conclusion, the result shows that major stress direction is from NE and SW for Outcrop 1a while for Outcrop 1b, the major Stress direction is from NW and SE.

Based on the rose diagram analysis below:

Table 8: Rose Diagram analysis for outcrop 1a.

Number of Measurements	30
Largest class size	60%
Mean	195.10°
Standard Deviation	± 4.70°
Vector Magnitude	29.90
Consistency ratio	1.00

Table 9: Rose Diagram analysis for Outcrop 1b.

Number of Measurements	90
Largest class size	67%
Mean	-1.87°
Standard Deviation	± 20.10°
Vector Magnitude	84.46
Consistency ratio	0.94

4.2.5 Geological Map

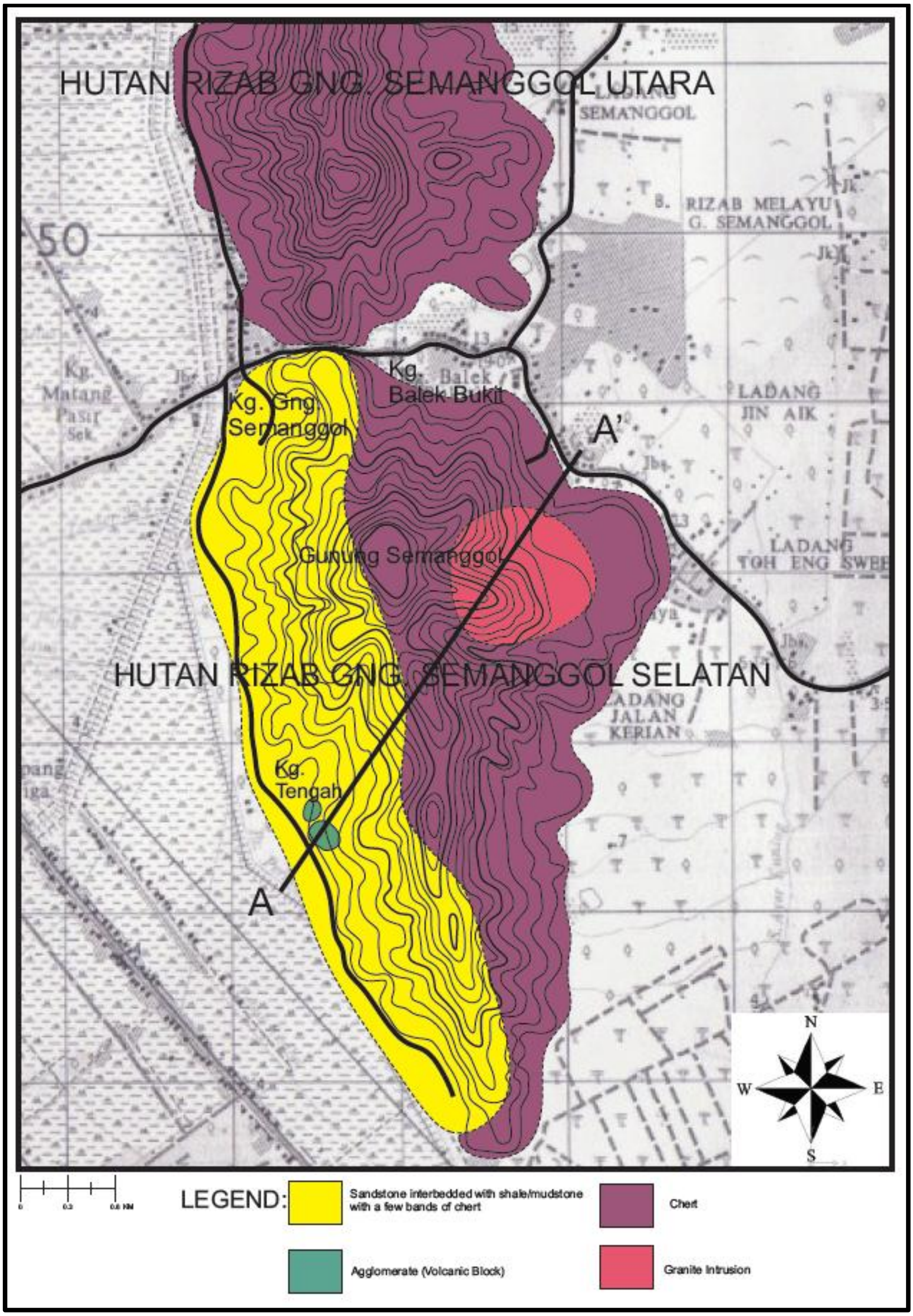


Figure 21: Geological Map of the transect area.

4.2.6 Cross Section

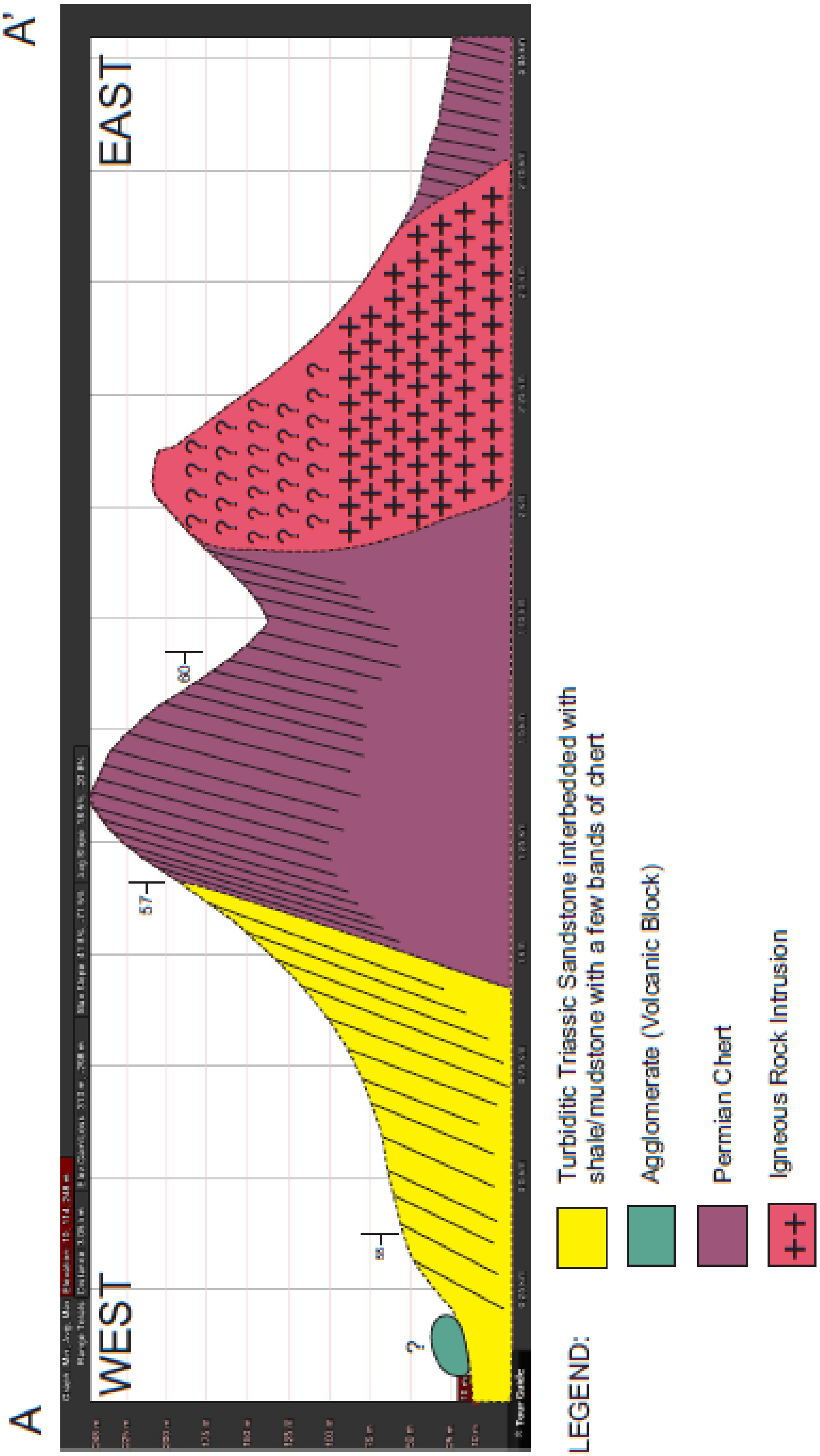


Figure 22: Cross section of the transect area.

4.3 Lab Analysis

4.3.1 Thin Section Analysis

Outcrop 1a and Outcrop 1b:

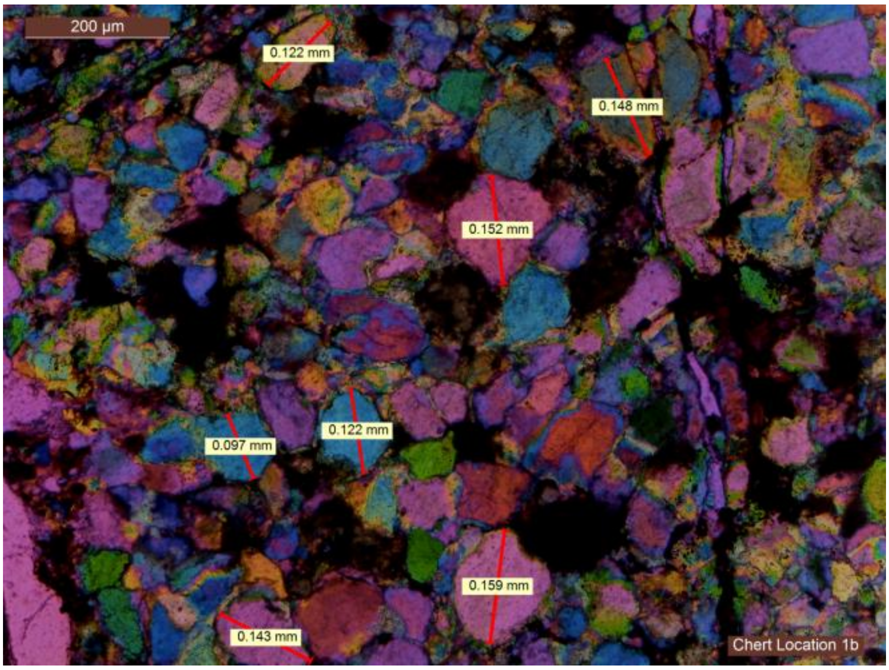


Figure 23: Cross Polarized of Sample Outcrop 1a

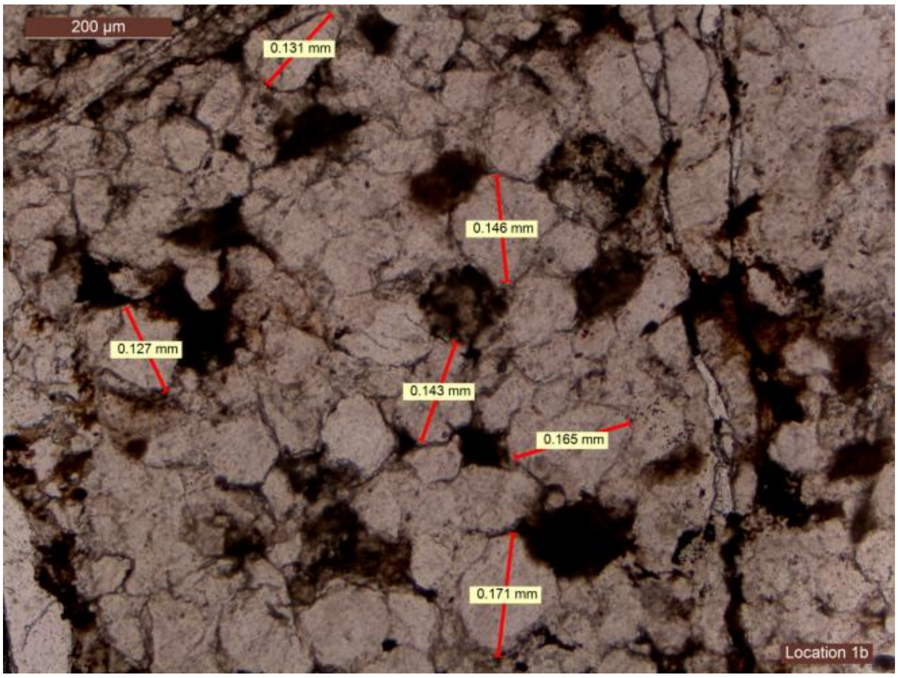


Figure 24: Plain Polarized of Sample Outcrop 1a

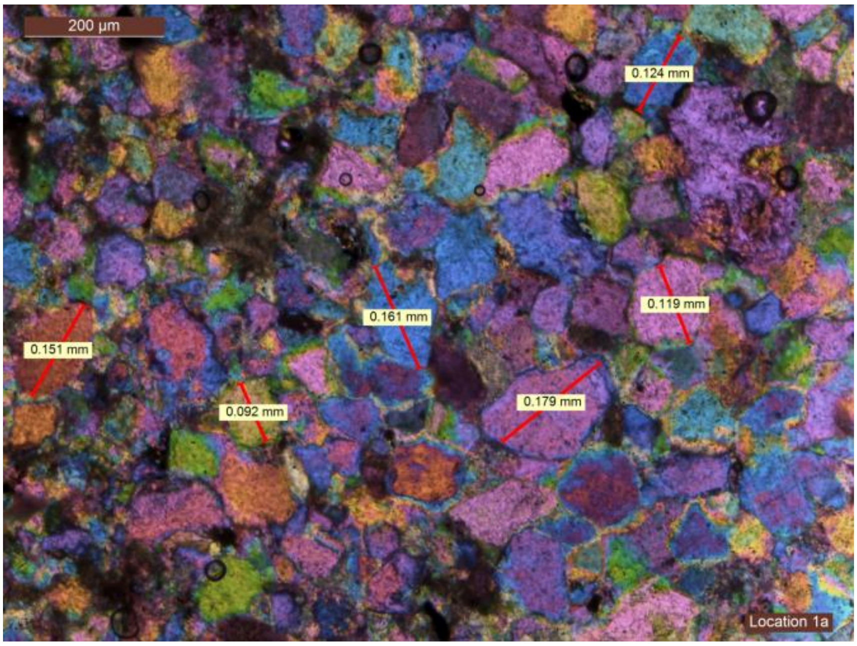


Figure 25: Cross Polarized of Sample Outcrop 1b.

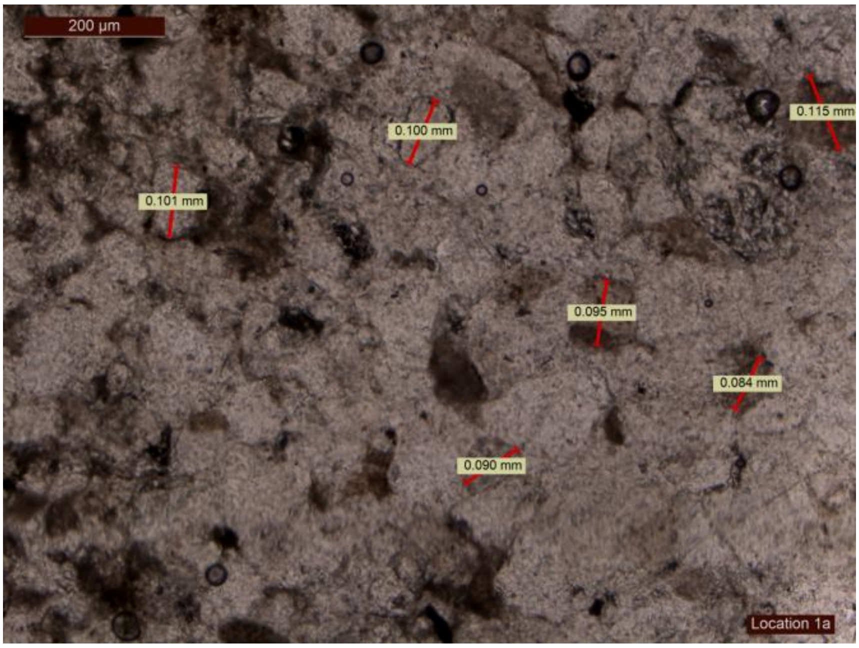


Figure 26: Plain Polarized of Sample Outcrop 1b

Macroscopic features:

The rocks are brown, reddish brown, yellowish browns, black in colour, due to the process of weathering and erosion. The texture is medium-fine texture with medium to fine of grain size. There is no structural formation on the surface of the rock. Crystallized of silica (SiO_2) is visible to naked eye. Cherts displaying irregular, crenulated laminations on a sub-millimetre to centimetre scale, consisting of variable thicknesses of stacked chert laminae with fine sandstone partings. This particular texture most probably originated by deposition from successive inundations by silica-rich waters, with periods of silica precipitations occasionally interrupted by the influx of detrial material.

Microscopic features:

Based on the result of thin section above, sample 1a showed that the grain size is about medium to fine grain. And there is also abundant of quartz mineral which are in blue to light blue in colour. The result also showed that the sample is a grain supported matrixquite a same texture and grain size under the microscope. The grain size of the mineral can be categorised as a medium grain size with a minor fine grain size. As we can see, there are quite a lot of quartz which is in greyish blue colour. Some biotite mineral also can be seen which is in greenish brown colour. There is no fracture is observed as we all know that pure chert has a splintery or conchoidal or sub-conchoidal fracture. Both of these sample are just a few bands of chert inside the sandstone. The chert matrix is in a brownish black in colour.

Both of these types of rock implies a tectonically active source area and depositional basin, with rapid erosion. The rocks are maybe associated with volcanic rocks, shales, and cherts of deep water origin.

4.3.2 X-Ray Fluorescence (XRF)

Table 10: Result of XRF Analysis for Sample 1a.

Formula	Z	Concentration	Status
Si	14	73.2 %	XRF 1
Al	13	8.86 %	XRF 1
K	19	7.06 %	XRF 1
Fe	26	3.76 %	XRF 1
Ca	20	2.39 %	XRF 1
Ti	22	1.84 %	XRF 1
P	15	1.70 %	XRF 1
Mg	12	0.425 %	XRF 1
Zr	40	0.360 %	XRF 1
Rb	37	0.0282 %	XRF 1
Sr	38	0.0181 %	XRF 1

Figure above shows the chemical composition data from the XRF of Sample 1a. The Silica content in Sample 1a shows the highest one with 73.2% of concentration. This high silica content indicates the abundant of quartz as well as feldspar in the sample. The concentration of Alumina content in the sample is 8.86% and the Potassium content in the sample is about 7% of concentration. The iron content in the sample shows quite low of concentration because the sample is taken from the area which has low percentage of weathering events occurred. That’s why, the colour of the sample is quite different with the other one which has more brownish in colour. The high content of silica indicates that this facies is a chert that coming from the deep marine environment setting.

Table 11: Result of XRF Analysis for Sample 1b

Formula	Z	Concentration	Status
Si	14	66.7 %	XRF 1
Fe	26	11.6 %	XRF 2
Al	13	8.89 %	XRF 1
K	19	6.17 %	XRF 1
Ca	20	2.29 %	XRF 1
P	15	1.70 %	XRF 1
Ti	22	1.53 %	XRF 1
Na	11	0.392 %	XRF 1
Mg	12	0.377 %	XRF 1
Zr	40	0.194 %	XRF 1
V	23	0.0892 %	XRF 1
As	33	0.0306 %	XRF 1
Rb	37	0.0245 %	XRF 1
Sr	38	0.0238 %	XRF 1

Figure above shows the chemical composition data from XRF analysis of Sample 1b. The silica content shows the highest percentage among the others which is about 67% of concentration. This result also shows that, the sample is quite being weathered and eroded as the iron content in the sample is quite high which is the 2nd highest compare to the others. The concentration of the iron is about 11.6%. The alumina and potassium are showing quite low of concentration which both of them have below than 10% of concentration in the sample. The others chemical composition which have lower than 1% can be determined as the impurities in the sample. Finally, the high content of silica indicates that the facies is also a chert that came from the deep marine environment setting of area.

4.4 Tectonic Evolution of the Semanggol Formation

4.4.1 Introduction

The Malay Peninsula forms an integral part of the SE Asian continental core of Sundaland and comprises of two tectonic blocks which are the Sibumasu in the west side and the Sukhothai Arc (East Malaya Block) in the east. Both of these blocks were assembled by the Late Triassic (Meltcalfe, 2013). The Malay Peninsula is characterised by three North – South belts, the Western, Central and Eastern Belts based on the distinct differences in stratigraphy, structure, magmatism, geophysical signatures, and geological evolution. The Western Belt forms part of the Sibumasu Terrane, derived from the NW Australian Gondwana margin in the Late Permian. In this paper we will mainly focused on the Western Belt and Central Belt only which Gunung Semanggol located. The collision between Sibumasu and the Indochina began in Early Triassic times and was completed by the Late Triassic. Triassic Cherts, turbidites, and conglomerates of the Semanggol Formation were deposited in a fore-deep basin constructed on the leading edge of Sibumasu and the uplifted accretionary complex. Collisional crustal thickening, coupled with slab break off and rising hot asthenosphere produced the Main Range late Triassic-earliest Jurassic S-Type granitoids that intrude the Western Belt and Bentong-Raub suture zone.

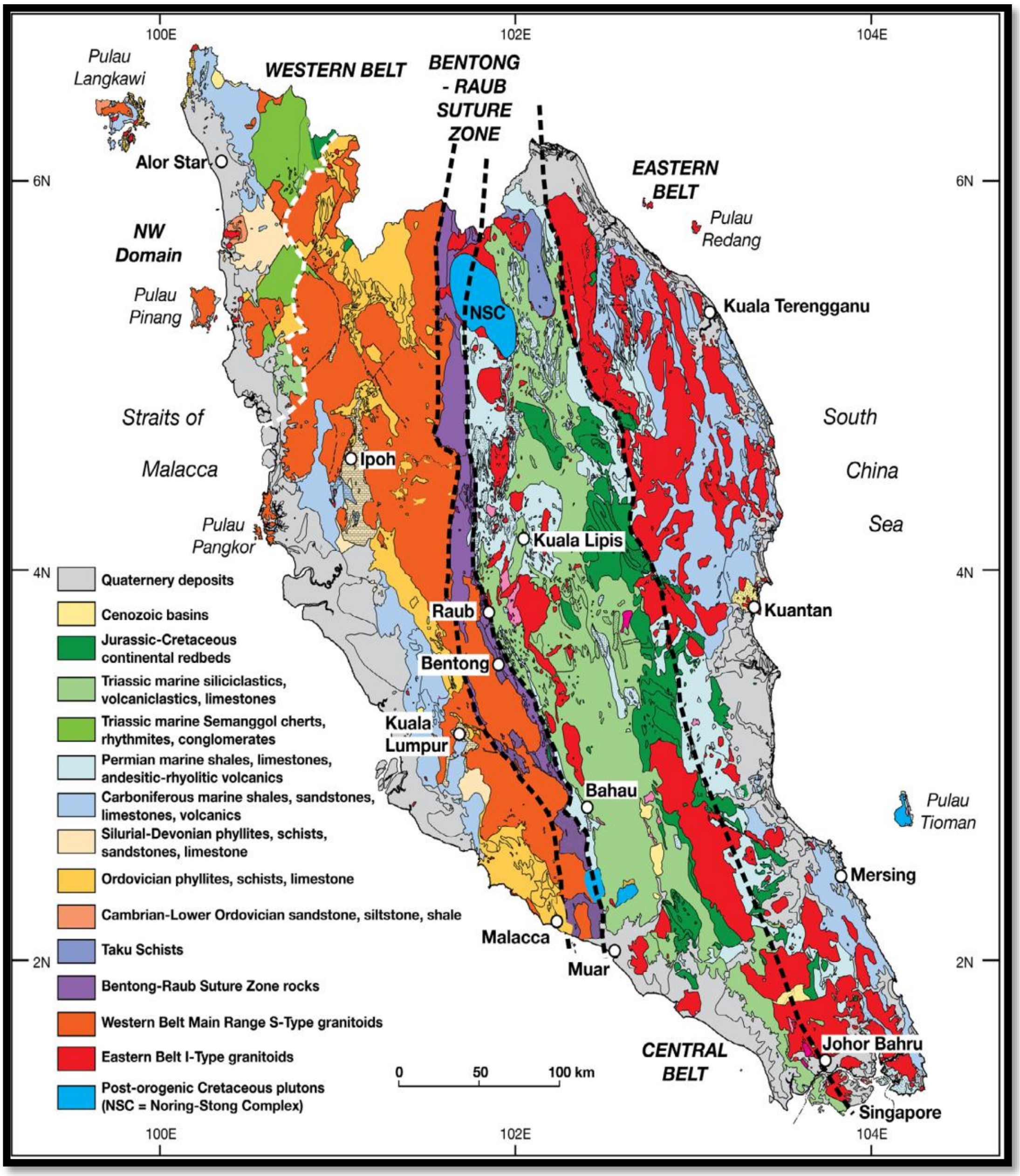


Figure 27: Simplified geological map of the Malay Peninsula, showing the three main belts in Peninsula Malaysia, after Tate *et al*. (2009).

4.4.2 Sibumasu Terrane

The Sibumasu Terrane (Metcalfe, 1984) includes the Shan Plateau of Burma, Northwest Thailand, Peninsular Burma and Thailand, Western Malay Peninsula (Western Belt) and NE Sumatra and possibly extends northwards into western China and Tibet. The block is bounded to the west and southwest by the Mogok Metamorphic Belt, the Andaman Sea, and the Medial Sumatra Tectonic Zone and to the east and northeast by suture representing the main Palaeo-Tethys Ocean.

The oldest dated rock on Sibumasu are middle Cambrian to Early Ordovician clastic of the Machinchang and Jerai formations in NW Peninsular Malaysia (Lee, 2009). Liew and McCulloch in 1985, have suggested that the age of crust beneath the Sibumasu Block in the Malay Peninsula is 1500-1700 Ma.

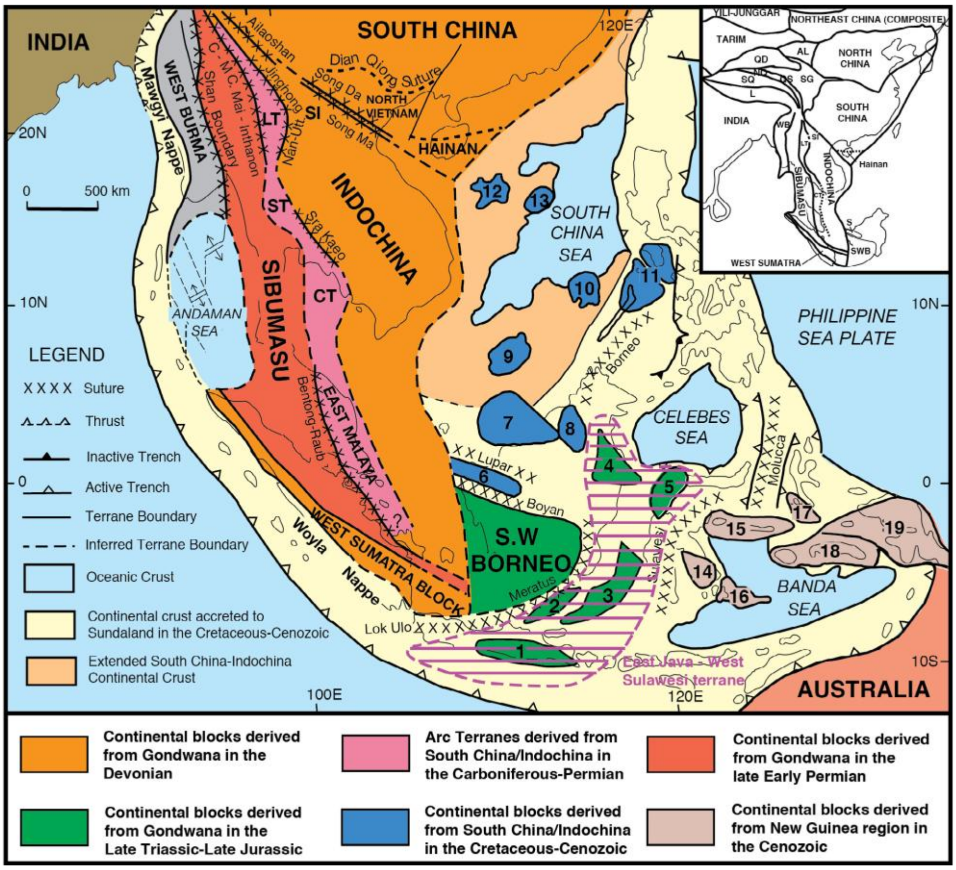


Figure 28: Distribution of continental blocks, fragments and terranes, and principal sutures of Southeast Asia. (Metcalfe, 2013)

4.4.3 Tectonic Evolution of the Transect Area

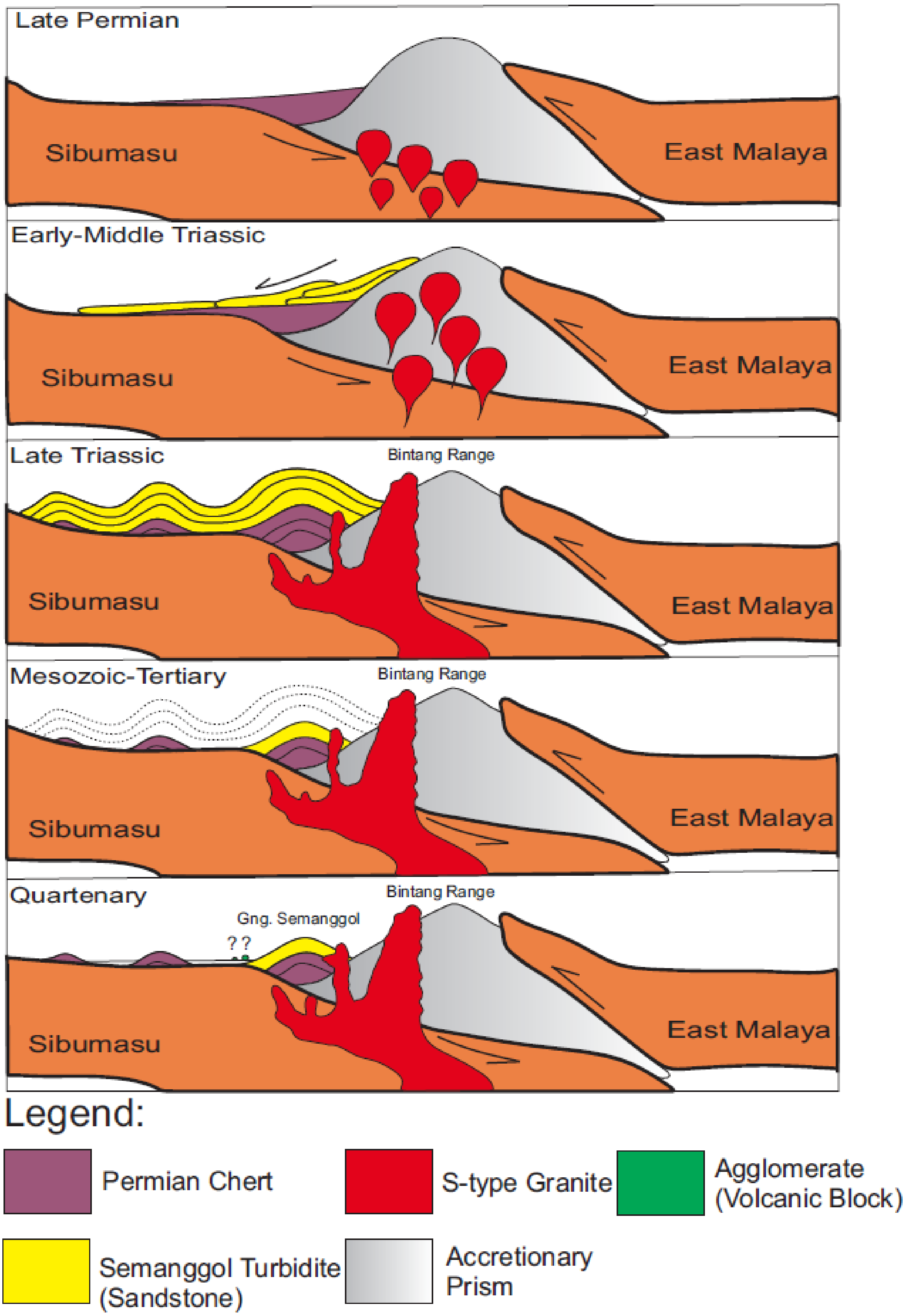


Figure 29: Tectonic evolution theory of the transect area, which is one of the Semanggol Formation. Modified from Metcalfe, 2013.

The Malay Peninsula is formed by two continental terranes that collided to each other which are the Sibumasu Terrane from the west and the Indochina (East Malaya Block) from the East. The collision resulted in three parts of Malay Peninsular which are, Western Belt of Peninsula caused by the Sibumasu Terrane and Central and Eastern Belt of the Peninsula caused by the East Malaya block. Both of these blocks are separated by the Bentong-Raub suture zone that preserves remnants of the Devonian-Permian Paleo-Tethys ocean basin (Metcalfe, 2013). Basically, the Sibumasu Terrane is come from the NW Australia Gondwana based on the biogeography, tectonostratigraphy, basement age, palaeoclimate, and palaeolatitude data and it is

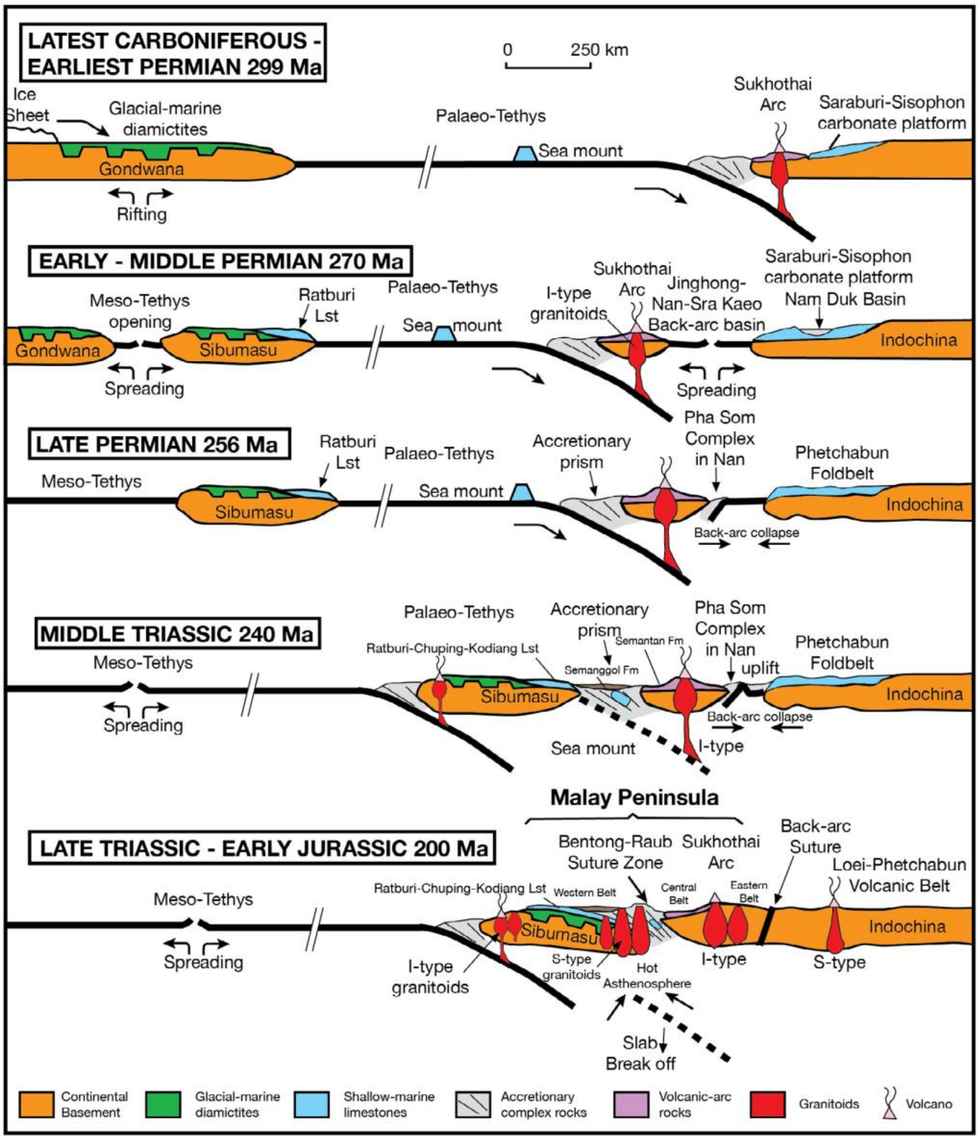


Figure 30: Showing the tectonic evolution of Sundaland (Thailand - Malay Peninsula) and evolution of the Sukhotai Arc (East Malaya Block) during Late Carboniferous-Early Jurassic times. (Metcalfe, 2013)

interpreted to have been part of the NW Australian Gondwana margin during Cambrian-Early Permian times.

The Central and Eastern Belts of the Malaya Peninsula, which are part of the East Malaya Block, which has a marginal Indochina Block continental basement. The flora and faunas found in the Eastern Belts of Malaya Peninsula are totally different with the Western Belt of Malaya Peninsula. This can proof that, the Eastern Belts do not exhibit any Gondwana elements.

After the seperation of Sibumasu Terrane from the Gondwana in Early – Middle Permian because of the Meso-Tethys opening and spreading of Sukhothai Arc from the Indochina block, both of these block start to collide to each other in about Late Permian. The Semanggol formation is formed when the Sibumasu Block subducted under the East Malaya block, and at the same time, the accretionary prism from the East Malaya block is thickening above the leading edge of Sibumasu Block. After the event of crustal thickening happened, there are some turbidity deposited towards the West side from the accretionary prism during the Early-Middle Triassic age. The turbidity deposition includes, the Triassic Chert, and turbiditic sandstones that are deposited to form Semanggol Formation which is in the transect area known as Gunung Semanggol. After the deposition occurred, the force coming from the Sibumasu Block towards the East is still continuous until another event occurred on Semanggol Formation which is the Semanggol folding event. There are two kinds of folding events occurred, the early and also the late folding. Both of these folding are occurred in the Late Triassic. The late folding of Semanggol Formation at Gunung Semanggol make the deposition highly tilted like we can see now at the outcrops exposed. During the folding events occurred, force coming from the East Malaya block also still in progress that make the S-Type Granite exhumed from the Sibumasu Block just about 20 to 30 KM eastly from the Gunung Semanggol, which is now known as Bintang Granite Range which located just next to the Central Belt of Malaya. Probably during the Mesozoic-Tertiary period, erosion and non-deposition occurred on the Gunung Semanggol makes some of the folded sandstones interbedded with cherts being eroded and turbidity sandstones deposited on top of the formation. This thick bedded sandstones are clearly visible found at the Outcrop 1b and also at the Northern Gunung Semanggol. In addition, there were also probably two recent volcanic blocks found on the west face of Gunung Semanggol. These volcanic blocks are most probably coming from the super eruption of Toba in Sumatra about 70,000 years ago. This theory is applied because, eruption of Toba is one of the biggest volcanic eruption in this world which is about total 13,000 km3 volcanic rocks and ashes being diverted around South East Asia.

CHAPTER 5

CONCLUSION AND RECCOMENDATION

As the conclusions, from this discussion and results, the author will be able to know and identify the geological setting of the West Face of Southern Gunung Semanggol area including the structural geology, sedimentary features, lithology and of course the lithofacies of the area. Besides that, a good geological map also is being mapped in details to show the geological features including the lithology, the structural geology and also the contact between different lithology. Structural analysis map and traverse map also are mapped in details to display the stress direction of the outcrops based on the strike direction data taken during the fieldwork. Last but not least, the theory and model of the tectonic evolution of the transect area is being generated and modified based on the Metcalfe, 2013 model. The model generated is just based on the lithofacies found during the research is conducted. So, there are a lot of works need to be done in future to confirm the theory. The most important things, is to date the age of the rocks to differentiate between Permian and Triassic period of rocks. Other than that, the sample also should be taken to lab analysis to determine the composition of the rock especially the agglomerate found at location 2a and 2b, because it is important to determine either it is from the volcanic explosion or just a turbidite conglomerate from the accretionary prism during the collision of Sibumasu and East Malaya block. Jungle traverse also need to be done to find more outcrops especially on the top of Gunung Semanggol to confirm the main lithofacies of Semanggol Formation in Southern Gunung Semanggol area.

REFERENCES

Burton, C. (1970). *The Geological and Mineral Resources of the Baling Area, Kedah and Perak.* Ipoh Department of Geological Survey, West Malaysia.

Burton, C. (1973a). Chapter 5: Mesozoic. In *D.J. Hutchison*, *Geology of Malay Peninsula* (pp. 97-141).

Burton, C. (1988). The Geological and Mineral Resources of the Bedung Area, Kedah, West Malaysia. *Vol 7 of Map Bulletin, Geological Survey Malaysia*.

Committee, T. M.-T. (2006). Geology of the Gubir - Sadao Transect Area Along the Malaysia-Thailand Border. *The Malaysia-Thailand Border Joint Geological Survey Committee*.

Courtier, D. (1974). *Geology and Mineral Resources of The Neighbourhood of Kulim,Kedah.* Ipoh: Geological Survey Department.

Group, T. M.-T. (2013). Litho and Biostratigraphic Correlations of Cherts Beds in Various Rock Units Along the Malaysia-Thailand Border. *Mineral and Geosciences Department, Malaysia. Department of Mineral Resources, Thailand*.

Hutchison, C. S. (n.d.). *Tectonic Evolution of Southeast Asia.* Kuala Lumpur: Department of Geology, University of Malaya.

Jasin, B. (1994). Middle Triassic Radiolara From the Semanggol Formation Northwest Peninsular Malaysia. *Warta Geologi, Vol. 20, No. 4,* 279-283.

Jasin, B. (1996). Discovery of Earlt Permian Radiolara from the Semanggol Formation, Northwest Peninsular Malaysia. *Warta Geologi, Vol. 22, No. 4,* 283-287.

Jasin, B. (1996). Permo-Triassic Radiolaria from the Semanggol Formation, Northwest Peninsular Malaysia. *Journal of Asian Surveys, Vol. 15, No.1*, 43-53.

Jasin, B., & Zaitun, H. (2011). Radiolarian Biostratigraphy of Peninsular Malaysia. *Bulletin of the Geological Society of Malaysia 57,* 27-38.

Jasin, B., Zaiton, H., & Siti, N. (2007). Black Silicieous Deposits in Peninsular Malaysia: Their Occurence and Significance. *Geological Society, Bulletin 53,* 103-109.

Jasin, B., Zaiton, H., Said, U., & Saad, S. (2005). Permian Radiolarian Biostratigraphy of the Semanggol Formation, South Kedah, Peninsular Malaysia. *Geological Society Malaysia, Bulletin 51*, 19-30.

Meltcalfe. (2013). Tectonic Evolution of the Malay Peninsula. *Journal of Asian Earth Sciences 76*, 195-213.

Metcalfe. (2012). Tectonic Evolution of the Malay Peninsula. *School of Environmental and Rural Science, University of New England, Journal of Asian Earth Sciences, Vol. 76*, 195-213.

Metcalfe, I. (1984). Stratigraphy, Palaeontology and Palaeography of the Carboniferous of Southeast Asia. *Member of Society Geology France, No. 147*, pp.107-118.

Yahoo Answer. (2009). Retrieved February 10, 2014, from Yahoo: http://uk.answers.yahoo.com/question/index?qid=20090527030030AAUsGxg

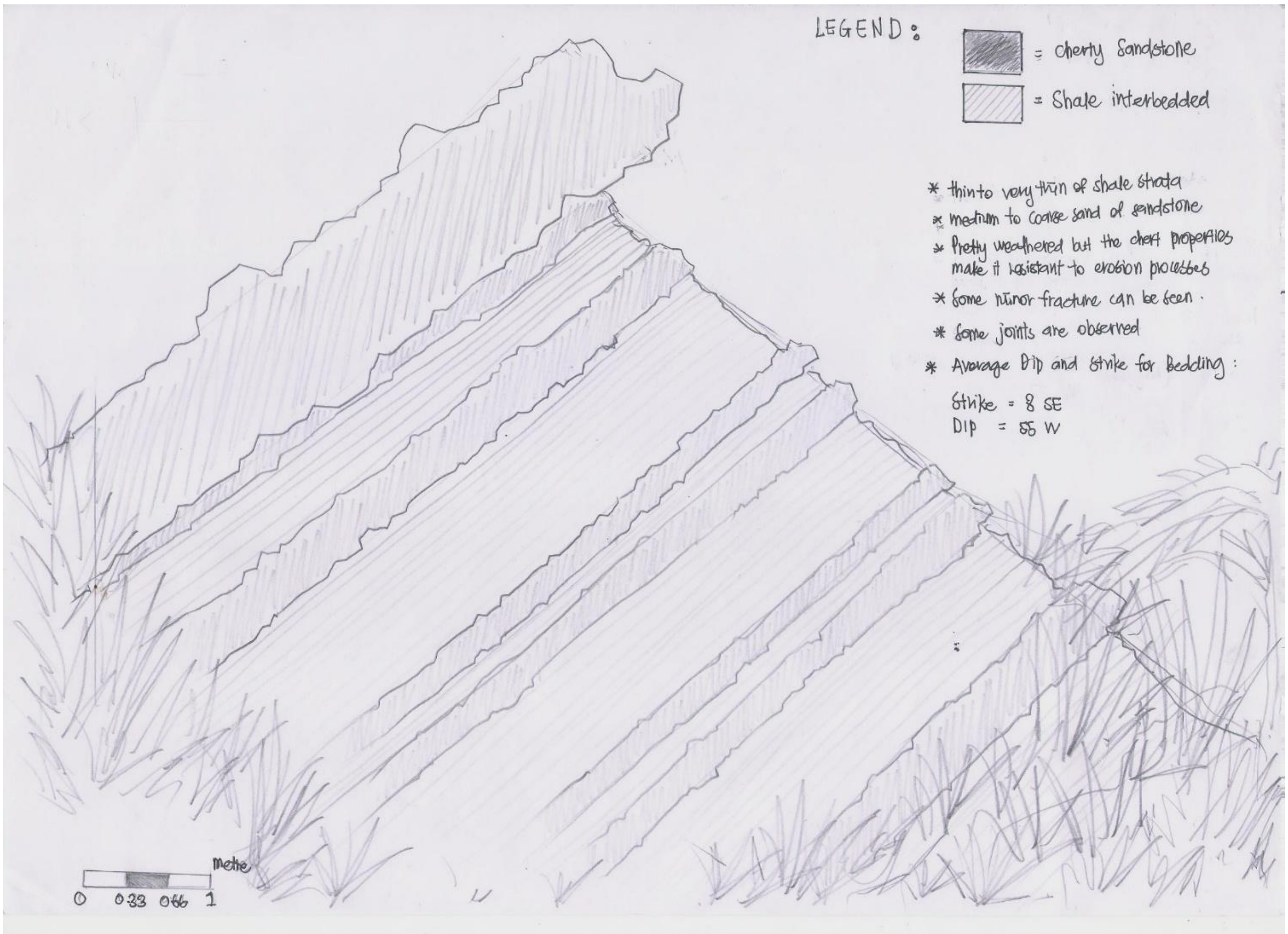
Yee, F. (1974). *Geology and Mineral Resources of The Taiping - Kuala Kangsar Area Perak Darul Ridzuan.* Ipoh and Kuala Lumpur : Geological Survey Headquarters and Geological Survey Laboratory.

Zaiton, H., Norshida, M., & Azrelawati, A. (2009). Thrust in the Semanggol Formation, Kuala Ketil, Kedah. *Bulletin of the Geological Society of Malaysia 55*, 61-66.

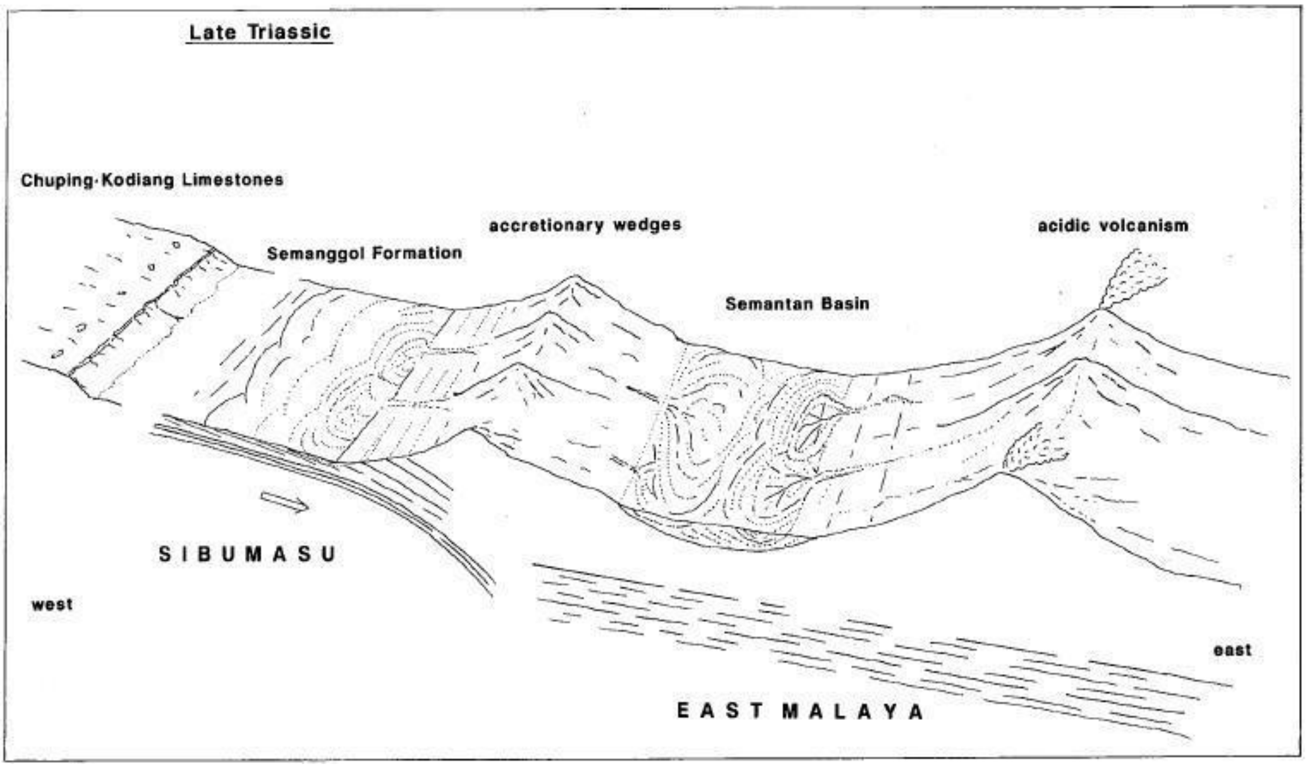
APPENDICES

Appendix 1: Shows the thick turbidite sandstone on top of the bedded cherts found at Northern Gunung Semanggol.

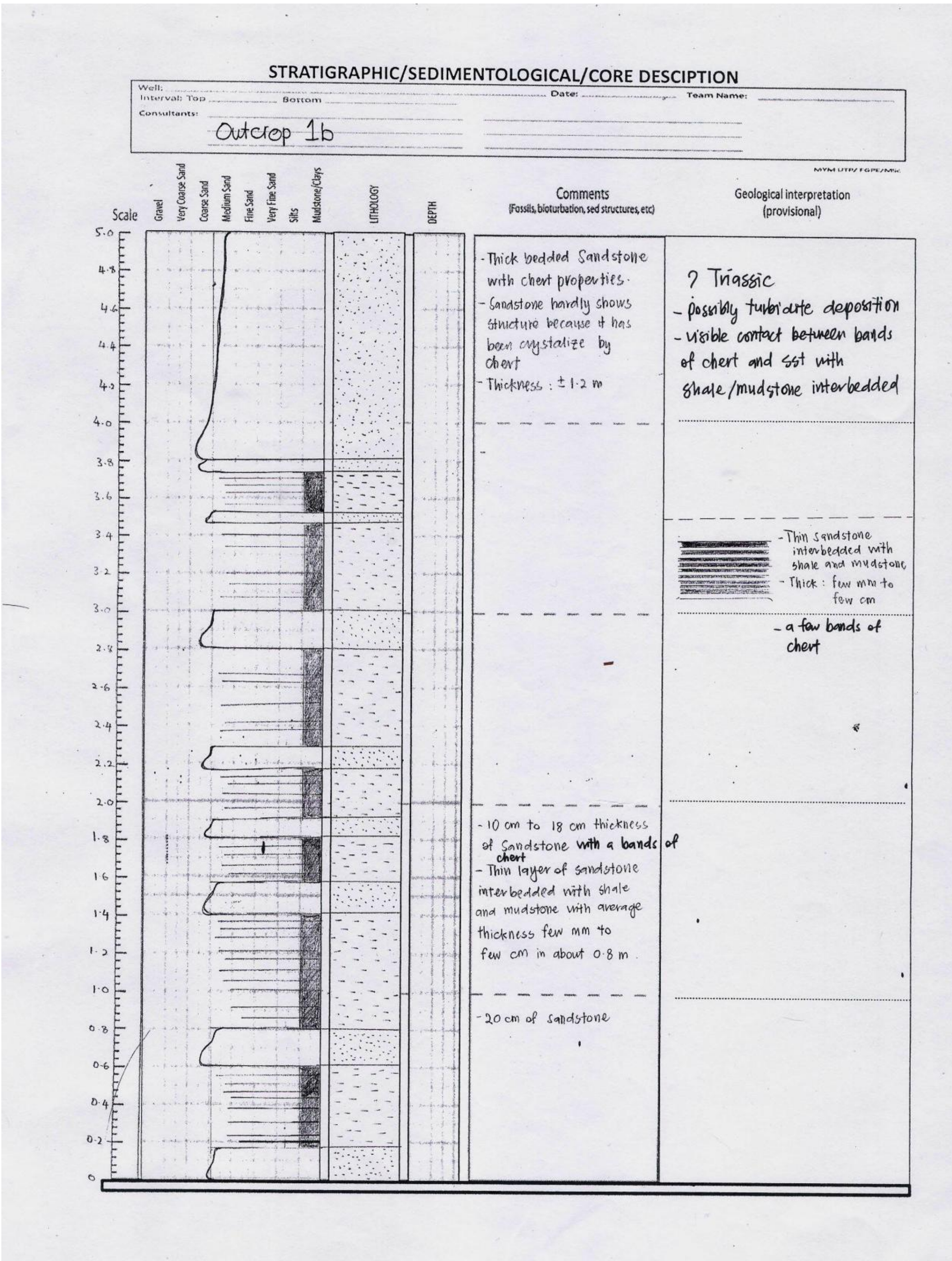
Appendix 2: Abandoned of quarry, possibly an intrusion of igneous rock found at Eastern Face of Southern Gunung Semanggol.



Appendix 3: First draft of sketch during the fieldwork at outcrop Location 1b.



Appendix 4: Model of formation of Semanggol Formation during Late Triassic period in term of tectonic evolution.



Appendix 5: Lithology log sketched at outcrop 1b.